

CLAIMS

- 1 1. A system for synchronizing dependencies upon a set of persistent consistency
2 point images (PCPIs) among a set of computers, the system comprising:
 - 3 means for identifying a dependency upon the set of PCPIs;
 - 4 means for creating a set of soft locks, each soft lock in the set of soft locks associ-
5 ated with each of the PCPIs in the set of PCPIs; and
 - 6 means for transmitting the set of soft locks to one or more of the set of computers.
- 1 2. The system of claim 1 wherein the set of computers comprises a set of storage
2 appliances.
- 1 3. The system of claim 1 wherein each soft lock comprises a PCPI identifier field, a
2 type field and a string field.
- 1 4. The system of claim 3 wherein the string field comprises user visible information.
- 1 5. The system of claim 3 wherein the string field identifies an application that de-
2 pends upon the PCPI associated with the soft lock.
- 1 6. The system of claim 3 wherein the type field identifies a type of data in the string
2 field.
- 1 7. The system of claim 6 wherein the type of data comprises an owner name.
- 1 8. The system of claim 6 wherein the type of data comprises a destination path.
- 1 9. The system of claim 6 wherein the type of data comprises a qtree name.

- 1 10. The system of claim 1 wherein the means for transmitting the set of soft locks to
- 2 one or more of the set of computers further comprises:
 - 3 means for transmitting the set of soft locks before an asynchronous mirroring
 - 4 process; and
 - 5 means for transmitting the set of soft locks after an asynchronous mirroring proc-
 - 6 ess.
- 1 11. A method for synchronizing dependencies upon a set of persistent consistency
- 2 point images (PCPIs) among a set of computers, the method comprising the steps of:
 - 3 identifying a dependency upon the set of PCPIs;
 - 4 creating a set of soft locks, each soft lock in the set of soft locks associated with
 - 5 each of the PCPIs in the set of PCPIs; and
 - 6 transmitting the set of soft locks to one or more of the set of computers.
- 1 12. The method of claim 1 wherein the set of computers comprises a set of storage
- 2 appliances.
- 1 13. The method of claim 1 wherein each soft lock comprises a PCPI identifier field, a
- 2 type field and a string field.
- 1 14. The method of claim 13 wherein the string field comprises user visible informa-
- 2 tion.
- 1 15. The method of claim 13 wherein the string field identifies an application that de-
- 2 pends upon the PCPI associated with the soft lock.
- 1 16. The method of claim 13 wherein the type field identifies a type of data in the
- 2 string field.
- 1 17. The method of claim 16 wherein the type of data comprises an owner name.

- 1 18. The method of claim 16 wherein the type of data comprises a destination path.
- 1 19. The method of claim 16 wherein the type of data comprises a qtree name.
- 1 20. The method of claim 1 wherein the step of transmitting the set of soft locks to one
2 or more of the set of computers further comprises the steps of:
3 transmitting the set of soft locks before an asynchronous mirroring process; and
4 transmitting the set of soft locks after an asynchronous mirroring process.
- 1 21. A storage system for use in a storage system environment for communicating de-
2 pendencies upon a set of persistent consistency point images (PCPIs) among a set of stor-
3 age systems, the storage system comprising:
4 a storage operating system having a file system that implements PCPIs;
5 an application executing on the storage system, the application adapted to imple-
6 ment a soft lock to communicate a dependency with a specific PCPI; and
7 a network protocol module of the storage operating system, the network protocol
8 module operatively interconnected with the application and adapted to transfer the soft
9 lock to one or more storage systems in the set of storage systems.
- 1 22. The storage system of claim 21 wherein the application comprises an asynchro-
2 nous mirroring application.
- 1 23. The storage system of claim 21 wherein the soft lock comprises a PCPI identifier
2 field, a type field and a string field.
- 1 24. The storage system of claim 23 wherein the string field comprises user visible in-
2 formation.

- 1 25. The method of claim 23 wherein the string field identifies an application that de-
- 2 pends upon the PCPI associated with the soft lock.

- 1 26. The method of claim 23 wherein the type field identifies a type of data in the
- 2 string field.

- 1 27. The method of claim 26 wherein the type of data comprises an owner name.

- 1 28. The method of claim 26 wherein the type of data comprises a destination path.

- 1 29. The method of claim 26 wherein the type of data comprises a qtree name.

- 1 30. A method for propagating soft locks through a cascaded chain of storage systems
- 2 comprising at least a downstream storage system and an upstream storage system, the
- 3 method comprising the steps of:
 - 4 identifying a set of persistent consistency point images on the upstream storage
 - 5 system that require a soft lock to be set;
 - 6 creating soft locks for the identified set of persistent consistency point images;
 - 7 sending the created soft locks to the upstream storage system; and
 - 8 performing an asynchronous mirroring process to mirror local data to the down-
 - 9 stream storage system.

- 1 31. The method of claim 30 further comprising the steps of:
 - 2 determining if a new persistent consistency point image exist on the downstream
 - 3 storage system;
 - 4 identifying, in response to a new persistent consistency image existing on the
 - 5 storage system, a set of additional soft locks on the downstream storage system; and
 - 6 sending the additional set of soft locks to the upstream storage system.

- 1 32. The method of claim 30 wherein the soft lock comprises a data structure having
- 2 an entry identifying a resource identifier and an identifier of a locking data set.

- 1 33. The method of claim 32 wherein a resource identifier identifies a persistent con-
- 2 sistency point image that the soft lock protects.

- 1 34. The method of claim 32 wherein the identifier of a locking dataset identifies a re-
- 2 source on a downstream system that requires the use of the persistent consistency point
- 3 image identified in the resource identifier.

- 1 35. The method of claim 30 wherein the step of identifying a set of persistent consis-
- 2 tency point images on the upstream storage system that requires a soft lock to be set fur-
- 3 ther comprises the steps of:
 - 4 identifying a set of persistent consistency point images that are in common be-
 - 5 tween the upstream storage system and the downstream storage system; and
 - 6 identifying a set of persistent consistency point images that have a soft lock set
 - 7 from one or more storage systems located downstream from the downstream storage
 - 8 system.

- 1 36. The method of claim 30 wherein the downstream storage system comprises a
- 2 storage system to which mirrored data is transferred.

- 1 37. The method of claim 30 wherein the upstream storage system comprises a storage
- 2 system from which mirrored data is transferred.

- 1 38. A cascaded set of storage systems interconnected via one or more networks, each
- 2 of the storage systems comprising:
 - 3 a storage operating system executing, the storage operating system including a
 - 4 mirroring application adapted to create and maintain soft locks on the storage systems of
 - 5 the cascaded set of storage systems.

- 1 39. The cascaded set of storage systems of claim 38 wherein the mirroring application
- 2 implements a volume-based asynchronous mirroring process.
- 1 40. The cascaded set of storage systems of claim 38 wherein the mirroring application
- 2 implements a qtree-based asynchronous mirroring process.
- 1 41. The cascaded set of storage systems of claim 38 wherein each of the soft locks
- 2 comprises a data structure having an entry defining a resource identifier and an entry
- 3 identifying a locking dataset.
- 1 42. The cascaded set of storage systems of claim 38 wherein the mirroring application
- 2 is further adapted to propagate the soft locks to one or more of the storage systems in the
- 3 cascaded set of storage systems.
- 1 43. A storage system for use in a cascaded set of storage systems having at least an
- 2 upstream storage system, the storage system comprising:
 - 3 means for identifying a set of persistent consistency point images on the upstream
 - 4 storage system that require a soft lock to be set;
 - 5 means for creating soft locks for the identified set of persistent consistency point
 - 6 images; and
 - 7 means for sending the created soft locks to the upstream storage system.
- 1 44. The storage system of claim 43 further comprising means for performing an asyn-
- 2 chrous mirroring process to mirror local data to a downstream storage system.
- 1 45. The storage system of claim 44 wherein the storage system is operatively inter-
- 2 connected with the downstream storage system via a network.

- 1 46. The storage system of claim 44 wherein the storage system is connected to the
- 2 upstream storage system and the downstream storage system via a network.

- 1 47. The storage system of claim 43 further comprising means for performing an asyn-
- 2 chronous mirroring process to mirror local data to the downstream storage system.

- 1 48. A computer readable medium, including program instructions executing on a
- 2 storage system in a cascaded set of storage systems having at least an upstream storage
- 3 system and a downstream storage system, the computer readable medium including in-
- 4 structions for performing the steps of:
 - 5 identifying a set of persistent consistency point images that are in common be-
 - 6 tween the upstream storage system and the downstream storage system; and
 - 7 identifying a set of persistent consistency point images that have a soft lock set
 - 8 from one or more storage systems located downstream from the downstream storage
 - 9 system;
 - 10 creating soft locks for the identified set of persistent consistency point images;
 - 11 sending the created soft locks to the upstream storage system; and
 - 12 performing an asynchronous mirroring process to mirror local data to the down-
 - 13 stream storage system.

- 1 49. The computer readable medium of claim 19 wherein local data comprises data
- 2 stored on storage devices associated with a storage system executing the computer read-
- 3 able medium.